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Three Years of Natural Revegetation on the 1977 Bear Creek Burn in Interior Alaska

William Hanson

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March 1992

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INTRODUCTION

The interior of Alaska is a vast area characterized by cold soils which are often underlain by permafrost; a continental climate with great extremes in temperature; and the taiga, a pattern of boreal forest and tundra which is largely the result of past wildfires (Viereck, 1973; 1975). There is probably no force which influences the mosaic of taiga vegetation more than fire. Nearly one million acres of taiga burn each year, and almost all of interior Alaska has burned in the last 250 years (Barney, 1971b). Barney (1971a) estimated that 25 percent of the interior has burned more than once.

Prior to the initiation of fire control in 1940, the statewide average annual burned area ranged from 608,000 to 1.1 million hectares (ha) (Barney, 1971). Fire control between 1940 and 1969 reduced this to about 405,000 ha (Barney, 1971a), and between 1970 and 1978 the average has been only 243,000 ha burned yearly, ranging from 1,389 ha in 1964 to more than 2 million ha in 1959 (Hardy and Franks, 1963; Barney 1969; BLM 1978). In 1977, the third largest fire year (acreage) in history, 930,000 ha burned. Of the 152,154 ha that were burned in Anchorage District, 145,800 ha were attributed to the Bear Creek Fire (BLM, 1977).

Formal studies of the plant regeneration and plant community succession following fire in interior Alaska were first published by Lutz in 1956. His studies along with those by Foote (1976), Viereck et. al. (1979), and Zasada et.al.(1979) and with the excellent literature reviews by Viereck (1975) and Viereck and Schandelmeir (1980), provided the base on which these studies could be built.

By the 1970's, government agencies with land management responsibilities in Alaska urgently needed information about the effects of fire. When a very large wildfire swept through Interior Alaska in 1977, it was closely monitored by the Bureau of Land Management (BLM).

The Bear Creek Fire, which occurred in the central part of the state near the town of McGrath, covered many terrain and vegetation types. It burned 139,620 hectares with a wide range of intensities and severities. During the course of this fire, BLM recognized the excellent opportunity to learn more about succession processes after natural wildfire. Studies began almost immediately. This paper reports the results of the first three years' observations of the vegetative regeneration on the Bear Creek burn.

For purposes of this paper, the terms **burn** and **fire** are defined as follows:

Burn - the physical remnants after a fire, e.g., charred or scorched organic matter.
Fire - the active principle of burning, characterized by heat and light combustion.

The purpose of this study is to quantitatively describe and analyze plant community succession following fire in relation to:

1. Soils, weather and topography.
2. Preburn forest, scrub, and herbaceous communities.

3. Fire severity (the degree to which the burned soil and plant community is displaced).
4. Fire intensity (the amount of heat released by the fire).
5. Fire frequency.

DESCRIPTION OF THE STUDY AREA

LOCATION

The study area is located between the South Fork and Middle Fork of the Kuskokwim River in interior Alaska, approximately 130 miles northwest of Anchorage and 25 miles east-southeast of McGrath. It is further bounded by the Alaska Range on the south and the Kuskokwim River on the north. This area is similar to many other parts of the interior Alaskan taiga. Interior taiga has the highest fire frequency in the state.

PHYSIOGRAPHY

The study area lies within the Tanana-Kuskokwim lowlands (Wahrhaftig, 1965). These are nearly level glacial outwash plains and lacustrine basins, dissected by small streams and a few large glacial rivers. A series of three glacial ablation moraines extend west from the South Fork of the Kuskokwim in a crescent of small hills which rise 30 to 61m above the adjacent lowlands. With the exception of these moraines, the area has very little topographic relief. It appears as a sparsely forested lowland extending about 80 km from the Kuskokwim River at an elevation of 91 to 122 m to the base of the Alaska Range, where elevation is about 488 m.

SOILS

The soils are young and poorly developed. Along the major drainages and the moraines, the soils are warm, well-drained and are the most productive sites. Soil textures range from sandy and gravelly to loamy. Most of the lowland areas have much wetter and colder soils. They are usually underlain by permafrost and productivity is low. Textures range from loamy to silty.

CLIMATE

The climate is continental with long, cold winters and short, cool summers. Winter temperatures range between -17° and 11° with a record low of -67° F. Summer temperatures range between 48° and 73° F, with a record high of 90° F. Wind is a major natural force affecting the area especially near the Alaska Range. A calm day is rare. Wind speeds generally range between 7m/sec. and 18m/sec. Mean annual precipitation is 45 cm. mostly accumulated in snowfall.

VEGETATION

Prior to the Bear Creek Fire, vegetation consisted primarily of coniferous forest, low scrubland and herbaceous communities. Major forest types included black spruce, white spruce and mixed conifer/hardwood communities. A detailed description of the major plant communities in the study area is presented in the section, "Regeneration of Plant Communities."

FIRE HISTORY

Fire history in the study area was analyzed using BLM fire reports, tree ring analysis and historical reports. Three problems which affected fire frequency research included 1) Computer search of BLM fires is only available after 1957, 2) Tree species in interior Alaska have thin bark and shallow roots, and usually do not survive damage by fire. So there are relatively few fire scars to be found. 3) The area is remote and inaccessible and very few historical accounts are available.

Within the study area itself, our understanding of fire history is not very complete, although it is known that fire plays a major role in determining the mosaic and character of plant communities. Any attempt to look beyond the most recent generation of trees, which are 40 to 100 years old on most study plots, is frustrated by the scarcity of fire scars.

Examination of fire history in the units east and west of the study area may help to understand the history of fire within the Bear Creek unit. This entire region lies within the physiographic area called the Kuskokwim lowland (SCS, 1979). With minor exceptions, soils, topography and vegetation are very similar to the study area, although both adjacent areas may be more densely forested.

The area between the Windy Fork and Big River, bounded on the north by the Kuskokwim and on the south by the Alaska Range, is designated the Lone Mountain Unit (Malotte, 1980). In the past 22 years, three fires have been recorded in the Lone Mountain Unit; these fires burned a total of .4 ha. Within the Bear Creek unit, 11 fires burned a total of 155,895 ha for the same period.

The Tonzona unit is bounded on the southwest by the South Fork, on the north by the East Fork, by the Tonzona River on the east, and Alaska Range on the south (Malotte, 1980). This unit has had eight lightning-caused fires in the past 22 years, for a total of 4,884 ha (4,860 ha burned in one fire). This seems to be a similar pattern to the Bear Creek unit, although fewer large fires have been recorded.

Of the 21 burns from lightning-caused fires in the three units, 16 were under 4 ha, four were more than 400 ha and only one (22 ha) was between these extremes. The absence of lightning-caused fires of intermediate size can be explained in several ways. If weather conditions permit a fire to grow over a certain size, possibly four to 40 ha, the fire will generally continue to grow over 400 ha before it is suppressed by the weather. BLM fire suppression forces usually keep action fires under 4 ha with the exception of years when conditions are dry enough to have an area-wide fire problem. In all likelihood, a combination of these and other factors is responsible for fire size-class distribution.

The Bear Creek Fire burned during the 1977 fire season, which began with above-normal rainfall over most of the interior. In mid-June, an extended drying period began. This continued into September with temperatures 3° to 6°C above normal and rainfall as much as 60 percent below normal (BLM, 1978). While lightning occurrence was average, the extremely dry conditions caused a significant increase in the number of lightning-caused fires. The weather in Farewell closely followed statewide trends. In May, rainfall was 175 percent to 200 percent greater than average, and maximum temperatures were 1.5° to 2.2°C lower than normal. During the next three months, however, Farewell received only 25 to 50 percent of its normal rainfall and temperatures were 1° to 5.5°C above normal. The result was an extended drought.

On August 6, a 2 ha fire was discovered approximately 31 km east-southeast of McGrath and 9 km north-northwest of the Farewell Landing Field. Despite aggressive initial attack, by the end of the day, the fire had increased to 12 ha. By the next morning, direct fire attack had become impossible over much of the perimeter due to intense burning, increased wind speed, and heavy smoke. The fire continued to grow under extreme burning conditions, exhibiting erratic fire behavior. Active burning continued through the end of August, until the onset of cool, moist weather. After September 3, the fire gained only a little more acreage. The final burned area was 140,000 ha. The fire was declared out on October 6.

The Bear Creek Fire is not of an uncommon size. Winds up to 56m/sec.were a major factor affecting the rapid growth of Bear Creek Fire. A brisk wind, 3.5 m/sec. to 7 m/sec., is normal in this area, partially due to its proximity to the Alaska Range. Fires as large as the Bear Creek Fire and several times larger have occurred periodically in Alaska, Canada, the northern USSR, and Siberia. Lutz (1956) identified 41 separate fires in Alaska which burned more than 40,000 ha each between 1893 and 1956. The largest fire on record was the Iliamna Lake Fire of 1935 which burned more than 769,000 ha (Lutz, 1956).

Large fires have occurred repeatedly in the study area, probably due to the presence of continuous fire fuels and the paucity of natural fuel breaks. Even the largest natural barriers, such as the Windy Fork, were jumped occasionally by the Bear Creek Fire and this is probably not a rare case. In the absence of suppression actions and changes in weather, this fire might have burned many more miles to the north, east and west. Although historical evidence is scant, it is probable that fire suppression activities have not yet led to abnormal fuel loading in the area and the Bear Creek Fire was simply part of the normal functioning of the ecosystem.

The following historical account leads one to believe the past is no different than the present. In 1965, an article in *Alaska Magazine* described the experiences of a dog musher, I. Reed, who had crossed through this part of Alaska in 1920. He reported traveling through "fire blackened" terrain for one day prior to staying at Peluk Roadhouse and for three days afterward before he reached the town of McGrath. This description refers to a distance of at least 129 km. If the burns he described extended only 5 km on either side of the trail (a very small minimum); the area burned would have been more than 121,000 ha. It appears that much of the area burned in the Bear Creek Fire has also burned between 1900 and 1920, probably between 1910 and 1920.

FIRE FREQUENCY

Fire frequency has varied throughout the study area. Although analysis of tree age on the sample plots indicates that most of the area has burned within the last 100 years, some portions have not burned in more than 180 years. Others have burned twice in as few as five years.

Based on tree age and historical records, it appears that the fire cycle in the study area is considerably longer than the five years between Bear Creek and Farewell fires, yet much shorter than the 250 years reported by Barney (1971a). (Fire cycle is the average time required for a natural fire regime to burn over an area equivalent to the total area of an ecosystem (Heinselman, 1989) - this case, the total study area.) It averages 60 to 120 years under current conditions. Most plant communities are capable of burning within 20 years of the last fire, and this cycle is probably controlled by climatic influences. The frequency of drought conditions in conjunction with lightning occurrence is the most likely determinant of fire frequency.

The Bear Creek Fire partially or completely reburned nine areas previously burned between 1957 and 1977 (table 1; figure 1). Of the ten burns, seven were four ha or less in size; the Big River Burn was 2,430 ha, the Farewell Burn was 13,770 ha, and the Bear Creek fire was 140,000 ha. Nearly 6,075 ha of the 1972 Farewell Burn were reburned by the Bear Creek Fire. All of the fires were ignited by lightning between June 15 and August 6 with seven occurring in July. One fire occurred along a valley bottom; all others covered flat or rolling country.

The repeated occurrence of large fires in the same locations at short intervals is possible because the black spruce plant communities which dominate the area have a continuous layer of fire fuels over a thick organic mat. The only plan communities in the study which do not have a thick organic mat are those dominated by white spruce, hardwoods or tall shrubs. The organic mat protects the roots and underground reproductive parts of many plants, especially grasses, sedges and ericaceous shrubs. Grasses and sedges can regenerate quickly enough to provide a continuous layer of fine fuels a few years after burning. Almost all communities are capable of reburning within 10 to 20 years.

FIRE INTENSITY AND SEVERITY

Fire intensity is the measurement of heat released by a fire. A low intensity fire may not burn portions of the plant which are more than a meter above the ground and will usually leave many inclusions of unburned plants. A high intensity fire burns most of the above-ground plant cover, crowning in forest types.

Fire severity determines the route vegetative regeneration will take and refers to the amount of heat penetration into the forest floor. A very severe fire destroys most of the vegetative mat and organic layer leaving only mineral soil. Remaining organic matter is charred. Severity also refers to the degree the fire impacts the ability of a species to regenerate. Light, non-severe fires may scorch the surface of the mat but will not expose much mineral soil. A fire can be severe without high intensity if it continues to smolder over a long time. The severity of a fire is related to four primary factors: organic mat thickness, soil moisture, fire frequency and weather.

Viereck et. al. (1979) defined five classes of fire severity:

1. **Heavily burned**: deep ash layer present, organic material in the soil consumed or nearly so to mineral soil; no discernible plant parts remaining.
2. **Moderately burned**: organic layer partially consumed, shallow ash layer present, parts of woody twigs remaining.
3. **Lightly burned**: plants charred but original form of mosses and twigs visible.
4. **Scorched**: moss and other plants brown or yellow, but species usually identified.
5. **Unburned**: plant parts green and unchanged.

Table 1
Fires in the study area, 1958 to 1980

Fire Name	Date Discovered	Size Hectares	Burning Index	Rate of Spread[1]	Fuel [2]	Severity[3]
Peluk	7/09/63	4.00	8	3	N	U
Sheep Creek	8/09/63	.80	8	1	N	U
Big River	6/18/69	2,428.00	42	15 C	F	U
Farewell	7/07/72	13,720.00	38	3	F	2
Howard	7/11/72	.40	62	3	N	U
Renee	7/13/72	1.21	25	2	F	3
Pitka	6/15/76	1.62	36	2	F	3
Pitka	7/21/76	.40	01	2	N	1
Sheep Creek	7/24/77	.40	06	1	F	1
Medfra	7/13/77	.40	04	1	F	U
Bear Creek	8/06/77	139,620.00	01	3	N,F	1, 2, 3

[1] 1=low, 2=moderate, 3=high, 4=extreme, 15 C = 15 chains/hour

[2] N=non-forest land; F=forest land

[3] U=unknown; 1=severe, 2=medium, 3=light

A map of burn intensity (figure 2) was developed by manually interpreting single band LANDSAT imagery from fall, 1978. The mapped polygons usually corresponded well to patterns on the ground color, were not always a good indicator of the severity class. For example, light-colored mineral soil exposed by very severe fires is difficult to distinguish from light-colored vegetation or scorched mosses. Despite these problems, the imagery proved to be very useful when used in conjunction with ground examinations to provide a permanent record of regional burn patterns. Many of the patterns disappeared within one to two years of the fire as dead trees and shrubs lost their scorched leaves.

The following discussion pertains to general observations of severity and intensity of the Bear Creek burn. Observations pertaining to these factors in specific plant communities are described under the appropriate community (see Regeneration of Plant Communities).

Sites which had a well-developed moss layer remained cold and moist despite the extended drought. The fire left a portion of the organic mat intact. Even in black spruce stands which sustained intense crown fire the impact on the organic mat was light to moderately severe.

Well-drained sites, which often had thinner organic mats, burned with heavy severity. The organic mat was completely destroyed, killing all plants except the most deeply rooted species such as aspen.

Survival of most species was related more to severity than to intensity. Crown fires can also have a severe effect on revegetation if the seed crop is destroyed. Upland white spruce communities burned with crown fires which eliminated the seed source. Most white spruce stands were located along drainage networks where crowning or torching did not occur. So many tree crowns were left intact .

The buildup of fuels due to previous fires will influence how future fires might burn. In white spruce/hardwood stands which suffered windthrow, the fuel loading is extremely heavy, and the stage will be set for very intense fires as soon as enough fine "carrier" fuels develop (probably within 10-20 years).

Plant Revegetation

METHODS

Prior to going into the field, initial vegetation cover and burn patterns were delineated using manual interpretation of preburn and postburn LANDSAT imagery. These maps, along with ground and aerial observations, were used to select 20 aerial flightlines. Twenty-four one-fourth ha plots were selected from photos taken along these flightlines . Each plot was as homogeneous as possible with respect to plant community and fire severity. During August 1978, the following data were recorded for each plot: physiography, relief, elevation, slope, aspect, drainage, estimated burn severity, scorch height on trees, number of trees standing (live and dead), number of trees fallen (burned and unburned), age and diameter of each tree species, evidence of erosion, wildlife use, fire suppression activity, depth of burn, depth to frozen ground and any special resource values or unusual observations.

Sixteen 1 m2 subplots (0.5m x 2m) were systematically selected within each plot and permanently marked with steel stakes. In each subplot, the percent coverage (Daubenmire, 1959), and frequency of occurrence were recorded for each species. The relative amounts of seven classes of forest floor material; deadwood, feces, burned litter, unburned litter, water, rock, and mineral soil, were also recorded. These observations were repeated in July 1979 and August 1980.

Based on field observation, pre-burn plant communities were described using Dyrness and Viereck (1986) as a guide. Hulten (1968) was used to identify herbs. Conrad (1956) was used for liverworts and mosses. Herbaceous common names are from Welsh (1974). Trees and shrubs, with their common names, are described from Viereck and Little (1972). When possible, pre-fire plant communities on each plot were identified from partially burned materials and unburned areas which survived the fire. Identification was very difficult on severely burned sites.

The postburn vegetation for each plot has been described by summarizing data collection on the subplots (percent coverage or density and frequency percent of occurrence).

RESULTS & DISCUSSION

Communities

Appendix A lists the common and specific names used. All species are referred to by their common names Each area is listed by its estimated preburn community (before 1977) and by a reference number. Specific information about individual postburn plots is located in Appendix B by plot numbers. An estimate of the probable pre-1977 plant communities is presented in Appendix C. Figure 3 is a general plant cover map based on manual interpretation of preburn LANDSAT imagery.

Closed Broadleaf Forest - Aspen (4-1) Before the 1977 fire, small aspen stands grew on southwest and west-facing slopes along the glacial moraines at elevations of 274 m to 335

m. These are the warmest and driest sites in the area because of their soils and exposure to sun and wind.

The stand is on a 45 percent south-facing slope of an ablation moraine ridge. The soil is a loamy pergelic cryochrept over sand and glacial till. This site is subject to strong winds which are channeled out of the Alaska Range by the drainage of the South Fork of the Kuskokwim River. Numerous aspen were broken at about half their height.

The trees in this preburned stand were 40 to 50 years old. Trees ranged from 6 m to 9 m in height, and had an average diameter of 8 cm. Average density was 280 trees/ha.

The understory of a nearby unburned stand was composed primarily of shrubby cinquefoil, bluejoint grass, and aspen seedlings and suckers. Fireweed and white spruce seedlings were also present.

The fire in this stand was severe, all crowns were destroyed and ground vegetation was reduced to mineral soil.

The site has been subjected to severe wind erosion because of its exposed position, During 1978, one year after the fire, thick dust clouds were driven into the air by 9 m/sec to 13 m/sec. winds. Drifts of windborne soil were observed on the lee side of rocks and fallen trees. Pedicelling of rocks and twigs also occurred, probably as a result of both wind and water erosion. Plant regeneration was hindered by severely burned substrate.

Table 2
Cover percentages of moss and mineral soil on three severely burned sites

Community	Moss			Mineral Soil			Herbaceous		
	1978	1979	1980	1978	1979	1980	1978	1979	1980
Closed Aspen	1	+	4	89	86	85	1	24	15
Dwarf Birch Shrubland (-)	+	16	50	45	30	3	–	–	–
White Spruce	60*	35	76	5	0	0	12	68	69

* It is believed that moss cover was near 0 percent and mineral soil near 100 percent immediately after the fire, but that mosses quickly covered most mineral soil before the site was sampled in 1978.
+ = trace

In three growing seasons since the fire, exposed mineral soil decreased four percent while moss cover increased three percent. This forms a stark contrast to other severely burned sites which were more sheltered from desiccating factors (table 2).

As might be expected, the lack of seedbed development was paralleled by a lack of development of a definable plant community. The only species which consistently increased production after the fire were aspen and grasses. Fireweed showed an early flush of growth (22 percent cover) in the second growing season, but was reduced to only eight percent cover in the third year.

Aspen is apparently the only species which survived the fire on this site. Roots deeply buried in mineral soil produced very few suckers in the first two years, but this species appeared to be firmly established with approximately 12,500 stems/ha by 1980. Small amounts of willow and rose were found on this site. Three years after burning, the site was still a very dry and harsh environment which will inhibit seed reproduction. See table 3.

Table 3
Species Occurring after Fire:
Broad Leaf Forest - Aspen Community (4-1)

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Betula papyrifera	0	12	0	–	–	–	0	12	0
Populus tremuloides	19	50	125	–	–	–	19	25	25
SHRUBS:									
Salix sp.	0	0	12	–	–	–	0	0	12
Rosa acicularis	–	–	–	0	+	1	0	12	38
HERBS:									
Calamagrostis canadensis	–	–	–	+	0	0	12	0	0
Elymus innovatus	–	–	–	0	2	0	0	38	0
Epilobium angustifolium	–	–	–	1	22	0	44	50	75
Equisetum pratense	–	–	–	0	0	+	0	0	12
Equisetum scirpoides	–	–	–	+	+	+	12	12	12
Festuca Spp.	–	–	–	0	0	10	0	0	50
Grass (unidentified)	–	–	–	0	0	5	0	0	38
MOSSES AND LIVERWORTS:									
Moss (unidentified)	–	–	–	1	+	4	25	12	88
Marchantia polymorpha	–	–	–	+	0	0	6	0	0

* (hundreds per hectare) Density data collected for trees and *Salix* species
\+ = Present

Closed Mixed Forest - Spruce/Birch/Poplar (14-1) Extensive stands of white spruce, balsam poplar, and white birch, in various combinations, grew along the South Fork and Windy Fork of the Kuskokwim River. They also formed "stringers" along many streams, small rivers, lakes and sloughs. These are flat, well-drained sites often underlain by gravel. Permafrost is deep or absent. Elevations range from 122 m to 366 m.

The sample stand is near the Windy Fork at an elevation of 198 m. It is elevated 2 m to 2.5 m above the active floodplain on a terrace. The soil is a sandy, warm and well drained soil. The pre-fire stand was composed of approximately 70 percent spruce and 30 percent balsam poplar and white birch. Trees ranged from 40 to 140 years of age, averaged 30 to 45 cm dbh, 10 to 20 m in height, and had an approximate density of 160 trees/ha. Nearby unburned stands have an understory of thin-leaf alder, high-bush cranberry, currant, bunchberry, red bearberry and feathermoss.

The fire burned very severely but without a crown fire, stopping at the edge of the terrace. The entire organic mat, which was three to 13 cm thick, and all understory plants were completely destroyed. All trees were killed.

Following the fire, most trees were blown down by the wind, leaving a "jackstraw" appearance with large trees scattered in every direction, one on top of another. In some places the fallen trees were piled 1.5 to 2 m high. Fallen spruce dropped their needles and seeds in concentrated piles 1 to 3 mm deep below their narrow canopies . It is likely that mineral soil was exposed over nearly 100 percent of the area. However, by August 1978, exposed mineral soil covered only five percent of the area while 56 percent of the seedbed consisted of *Marchantia polymorpha*, a liverwort community found after fire. Deadwood and unburned litter, primarily needles from dead spruce, made up the remaining ground cover.

Although mineral soil is considered the best seedbed for establishment of white spruce (Zasada and Gregory, 1969), the mulching effect of this thin layer of needles over mineral soil, the rapid invasion of *Marchantia polymorpha*, and the shade provided by fallen trees probably helped stabilize moisture conditions at the surface and may have influenced nutrient retention and availability. Balsam poplar and paper birch regeneration on this site appears to have been limited by the severity of the burn to seed reproduction.

Paper birch, white spruce, and balsam poplar, the principal tree species in the original stand, all demonstrated very good regeneration. This was apparently due to the high severity but low intensity of the fire, which killed all trees but left canopies and seeds unharmed. The seeds were mature because the fire occurred in August. An early season or crown fire would have destroyed this seed source (Zasada, 1978).

While white spruce and balsam poplar continued to increase in 1980, paper birch density decreased to half its 1979 density. Spruce reproduction increased from 10,000 seedlings/ha to 45,000 seedlings/ha (table 4).

Table 4
Density of tree seedlings in a burned Spruce/Birch/Poplar stand

Species	1978	1979	1980
White spruce	100	128	456
Balsam Poplar	31	125	621
Paper Birch	62	169	88

*hundreds per hectare

Zasada et. al. reported that only 23 percent of the white spruce seedlings produced during an excellent seed year under good germination conditions survived to the next year; only 18.5 percent survived for five years. Even if only 18.5 percent of the white spruce seedlings on this plot survived for five years, approximately 1,850/ha would be present. This is about 10 times better regeneration than found by Foote (1979).

There is an apparent discrepancy between the expected seedling density derived from Zasada's research and the observed numbers which increased 456 percent rather than decreasing 81.5 percent. This may have resulted from the combination of the proximity of living white spruce to the plot, with the occurrence of a good seed year, with optimum seedbed conditions, and good germination and growing conditions.

Although very few species have become established on this site, overall biomass production is much higher than in other burned communities. *Marchantia polymorpha* reproduced abundantly during the first year after the fire, covering 56 percent of the surface. In 1979, much of the *M. polymorpha* was brown and apparently dying. Coverage decreased to 35 percent, while unburned litter increased from 14 percent to 45 percent cover. In 1980 the plots were interpreted differently. Although the distal portions of the liverwort were brown, the bases were green and olive, and the entire plant was counted as living. This indicates that the increase in *Marchantia* in 1980 is an anomaly caused by method rather than an actual increase. Nevertheless, the *M. polymorpha* lost much of its vigor in 1979 and 1980. This may be related to the huge increase in fireweed production from 12 percent coverage in 1978 to 68 percent in 1979 and 69 percent in 1980. Typical plants were nearly a meter high and heavily shaded the ground. This shading effect was so prominent that it was very difficult to relocate and read subplots. The only other plants which became established in significant amounts were *Polytrichum* sp. and an unidentified feathermoss. See table 5.

Open Needle Leaf Forest - Black Spruce/White Spruce (11-1). This was an extensive community between the two most recent moraines in the southeast portion of the study area.

The sample stand is located on a well-drained flat portion of the outwash plain. Soil here is loamy, well-drained but cold. Permafrost is discontinuous or absent. This community had been composed of approximately equal amounts (percent coverage) of black spruce and white spruce with an overall canopy closure of more than 50 percent . Diameter, height, and age averaged 7 to 8 cm, 5.5 meters and 55 years for white spruce. For black spruce these values were 5 to 10 cm, 7 meters and 44 years.

The fire burned both severely and intensely, crowning and killing all trees. It removed all fire fuels, leaving no more than 5 cm of the original five to 15 cm of organic mat. Large patches of mineral soil were exposed. Mineral soil and burned organic matter had respective cover values of 10 percent and 80 percent in 1978.

Of the 16 species found on the plot in 1978, only prickly rose, bluejoint grass, and black spruce continued to increase in abundance or production through 1980. Bog blueberry decreased from a frequency of 94 percent in 1979 to 12 percent in 1980 (after an original increase from 38 percent to 94 percent between 1978 and 1979). Mountain cranberry, which had a frequency of 12 percent in 1978 and 88 percent in 1979, disappeared from the site in 1980. Labrador tea, Carex sp., an unidentified composite, and rock harlequin, which were present in 1978 and 1979, also disappeared in 1980. *M. polymorpha* decreased from seven percent cover in 1978 to two percent in 1980.

These trends seem to indicate that this site may have been subjected to severe desiccation between 1978 and 1980, even though these summers were considered to be wetter than average. See table 6.

Closed Mixed Forest - Spruce/Birch (6-1). Along the northeastern perimeter of the burn, the vegetation forms a distinct mosaic of black spruce-paper birch forest surrounded by sphagnum bogs. The forest occurs on areas raised .5 to 1 m above the bogs at an elevation of 134 m.

Table 5
Species occurring after Fire:
Closed Mixed Forest - Spruce/Birch/Poplar (14-1)

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Betula papyrifera	62	169	88	+	+	+	62	31	38
Picea glauca	100	128	456	+	+	+	100	75	38
Populas balsamifera	31	125	162	+	+	+	31	12	6
SHRUBS:									
Salix sp.	12	0	0	+	0	0	12	0	0
Dryas octopetala	–	–	–	0	+	0	6	0	0
Rosa acicularis	–	–	–	0	0	+	0	0	6
Salix myrtillifolia	–	–	–	0	0	+	0	0	+
HERBS:									
Compositae	–	–	–	0	+	+	0	6	6
Epilobium angustifolium	–	–	–	12	68	69	81	94	100
Galium spp.	–	–	–	0	0	+	0	0	44
MOSSES AND LIVERWORTS:									
Feathermoss	–	–	–	0	+	0	0	6	0
Moss (Unidentified)	–	–	–	4	+	8	94	19	94
Polytrichum sp.	–	–	–	0	0	2	0	0	62
Sphagnum sp.	–	–	–	0	0	+	0	0	6
Marchantia polymorpha	–	–	–	56	35	66	100	94	100

* (hundreds per hectare) Density data were collected for trees and *Salix* species
+ = Trace
-- = not tabulated

The stand on the study plot had a density of 350 to 450 trees/ha. Trees were as much as 12 cm in diameter and 60 years old. Black spruce growth was denser than paper birch, but canopy cover was the same for both species. Soil under the forest is a fine silty histic pergelic cryaquept, a cold and very poorly-drained soil. In 1980, ground water was found 28 cm below the remaining organic mat which is 23 to 34 cm thick. Continuous permafrost lay 53 to 61 cm below the surface in 1980. The surface is irregular and marked by numerous frost boils. It has a slope of less than three percent without any dominant aspect.

The surface fire crept with low severity through the raised forest between bogs leaving many fine fuels near the ground on trees and shrubs. About five to 25 cm of the original

35 cm of organic mat was consumed exposing only a small amount of mineral soil (five percent cover). All trees were killed.

In 1978 most of the seedbed consisted of burned organic matter (85 percent cover) and unburned litter (11 percent cover). Mosses had a cover value of 21 percent. By 1980, burned organic matter had been reduced to 52 percent cover and litter to two percent cover. Living mosses has increased to 43 percent cover.

Seedlings and sprouts from fire-killed stems had become very abundant by the end of the three-year period. The density of white birch increased from 5,600/ha in 1978 to 71,200/ha in 1980. Black spruce seedlings increased from 5,000/ha in 1978 to 40,000/ha in 1980.

Table 6
Species occurring after fire:
Open Needle Leaf Forest Black Spruce-White Spruce Community (11-1)

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Picea mariana	44	62	112	+	+	+	44	19	44
SHRUBS:									
Salix spp.	0	12	6	0	+	+	0	6	6
Betula nana	–	–	–	3	5	4	38	31	31
Ledum groenlandicum	–	–	–	+	0	0	6	0	0
Rosa acicularis	–	–	–	1	3	3	31	38	50
Vaccinium uliginosum	–	–	–	1	+	+	38	94	12
Vaccinium vitis-idaea	–	–	–	+	+	0	12	88	0
HERBS:									
Calamagrostis canadensis	–	–	–	6	9	12	62	44	56
Carex spp.	–	–	+	0	0	6	0	0	
Compositae (unidentified)	–	–	–	+	0	0	6	0	0
Corydalis sempervirens	–	–	–	+	+	0	12	6	0
Epilobium angustifolium	–	–	–	10	18	16	75	94	94
Equisetum scirpoides	–	–	–	+	+	+	19	6	12
Eriophorum sp.	–	–	–	0	0	1	0	0	6
Grass (unidentified)	–	–	–	0	+	0	0	6	0
Polemonium acutiflorum	–	–	–	2	5	2	38	38	62
MOSSES AND LIVERWORTS:									
Moss (unidentified)	–	–	–	5	37	30	100	100	94
Polytrichum	–	–	–	2	0	8	81	0	100
Marchantia polymorpha	–	–	–	7	5	2	88	62	69

*hundreds per hectare) Density data were collected for trees and *Salix* species

\+ = Trace

-- = not tabulated

A wide variety of shrub and herb species were found on the plot in 1978. These were primarily survivors of the original plant community. By 1980, Labrador tea had increased from one percent to 15 percent cover and mountain cranberry from two percent to seven percent. Other species which increased in canopy coverage between 1978 and 1980 included fireweed (six percent to 10 percent), cloudberry (three percent to eight percent), unidentified feather mosses (9 to 21 percent), sphagnum (5 percent to 9 percent), and *M. polymorpha* (four percent to 11 percent). Willow density increased from 600 stems/ha to 1,900 stems/ha. Only two new species, *Carex* sp. and Galium sp. appeared between 1978 and 1980. Prickly rose disappeared.

Table 7
Species Occurring After Fire
Closed Black Spruce - Paper Birch Community (6-1)

	Density * (Stems/ha)		Percent Cover		Percent Frequency	
Species	78	80	78	80	78	80
TREE SEEDLINGS:						
Betula papyrifera	56	712	+	+	66	75
Picea mariana	50	400	+	+	50	81
SHRUBS:						
Salix spp.	6	19	+	+	6	6
Betula nana	–	–	3	1	31	25
Empetrum nigrum	–	–	+	+	12	12
Ledum decumbens	–	–	1	15	56	75
Ledum groenlandicum	–	–	2	4	81	69
Rosa acicularis	–	–	+	0	6	0
Vaccinium oxycoccuos	–	–	+	1	31	44
Vaccinium uliginosum	–	–	4	4	81	62
Vaccinium vitis-idaea	–	–	2	7	81	75
HERBS:						
Calamagrostis canadensis	–	–	+	1	6	12
Epilobium angustifolium	–	–	6	10	44	44
Galium sp.	–	–	0	+	0	6
Rubus chamaemorus	–	–	3	8	56	56
Sedge (unidentified)	–	–	0	+	0	6
MOSSES AND LIVERWORTS:						
Feathermoss	–	–	+	+	12	6
Moss (Unidentified)	–	–	9	21	69	94
Polytrichum sp.	–	–	1	2	25	69
Sphagnum sp.	–	–	5	9	38	19
Marchantia polymorpha	–	–	4	11	56	62
LICHENS:						
Cladonia spp.	–	–	+	+	6	6

* (hundreds per hectare) Density data collected for trees and *Salix* species
+ = Trace
-- = not tabulated

The surface fire crept with low severity through the raised forest between bogs leaving many fine fuels near the ground on trees and shrubs. About five to 25 cm of the original 35 cm of organic mat was consumed exposing only a small amount of mineral soil (five percent cover). All trees were killed.

See table 7.

Closed Needle Leaf Forest - Black Spruce/Tamarack (13-1). Densely stocked black spruce-tamarack forests grew on the extensive outwash plains near the northcentral portion of the burn.

The plot is on a recently active floodplain. In 1978, it had a seedbed consisting of 15 cm of organic material over well-drained gravel. This plot supported a dense forest type with 3,000 to 6,400 trees/ha, ranging in diameter from one to 7 m, in height from one to 11.5 cm, and in age from 43 to 48 years. Although the fire here was an intense crown fire, the associated ground fire was of low severity, only burning to a depth of 5 cm, leaving 23 percent of the forest floor unburned.

Between 1978 and 1980, the burned organic component decreased to 68 percent. Unburned litter decreased from 12 percent to eight percent and deadwood increased from six percent to nine percent. Moss cover increased from one percent to six percent.

See table 8.

Open Needle Leaf Forest - Black Spruce/Tamarack (13-2). This community grew on the outwash plains, but on different soils than the Closed Needle Leaf Forest community.

Soil in the study plot is a sandy pergelic cryorthod over gravelly sand. Original organic mat thickness is unknown. It is warm and well-drained. Permafrost is absent or deep. The original plant community was open with 200 to 400 stunted trees per ha. Age ranged from 40 to 178 years for black spruce and from 49 to 75 years for tamarack. Diameters ranged from three to 6 cm at breast height. The understory was probably composed of Labrador tea, bog blueberry, dwarf arctic birch, and willows with a dense feathermoss mat.

The low-intensity fire scorched tree trunks to a height of 3 m and left many fine fuels on shrubs and tree saplings. Burn severity was moderate. Although no mineral soil was exposed, 89 percent of the forest floor surface was scorched or charred. This had decreased to 76 percent by 1980 and moss cover had increased from two percent to 15 percent. Standing water, which was not present in 1978, covered two percent of the area in 1980, primarily in very severely burned microsites where rocks were exposed. This may have been the result of melting ground ice or it may have been due to the very wet 1980 summer. Sporadic rain had fallen prior to sampling of the plot.

Low shrubs, principally Labrador tea, blueberry, and cranberry represented 14 percent cover compared to only three percent for herbs in 1978. Bluejoint grass was the only significant herb. These species continued to dominate the community through 1980 when total low shrub cover was 34 percent and total herb cover was 13 percent. The number of species in the community changed only slightly with dwarf arctic birch the most notable new species. It is likely that this species was present on the site but not in the subplots in 1978.

Table 8
Species occurring after fire:
Closed Needle Leaf Forest-Black Spruce/Tamarack Community (13-1

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Larix laricina	6	6	0	+	+	0	6	6	0
Picea Mariana	0	6	6	0	+	+	0	6	6
SHRUBS:									
Alnus tenuifolia	31	62	75	+	+	+	31	38	44
Betula glandulosa	40	0	50	+	0	+	44	0	6
Salix spp.	38	44	113	+	+	+	38	50	75
Salix arbusculoides	6	0	38	+	0	+	6	0	19
Salix glauca	0	0	25	0	0	+	0	0	19
Salix novae-anglae	31	0	19	+	0	+	31	0	19
Arctastophylos rubra	–	–	–	1	2	2	25	31	38
Betula nana	–	–	–	0	4	2	0	38	12
Ledum decumbens	–	–	–	1	+	4	44	12	38
Ledum groenlandicum	–	–	–	3	4	13	82	81	88
Potentilla fruticosa	–	–	–	+	+	1	19	19	19
Rosa acicularis	–	–	–	+	+	1	6	6	25
Vaccinium uliginosum	–	–	–	10	17	18	100	94	88
Vaccinium vitis-idaea	–	–	–	3	3	3	82	94	69
HERBS:									
Calamagrostis canadensis	–	–	–	0	0	+	0	0	6
Carex spp.	–	–	–	0	+	+	0	6	6
Cornus canadensis	–	–	–	+	1	1	31	50	25
Epilobium angustifolium	–	–	–	+	+	6	12	19	69
Equisetum arvense	–	–	–	2	2	4	88	62	75
Equisetum scirpoides	–	–	–	0	1	1	0	38	12
Rubus chamaemorus	–	–	–	1	1	1	38	38	25
MOSSES AND LIVERWORTS:									
Moss (unidentified)	–	–	–	1	5	14	56	75	94
Polytrichum	–	–	–	0	0	2	0	0	62
Marchantia polymorpha	–	–	–	+	+	+	12	6	6

* (hundreds per hectare) Density data were collected for trees, *Salix* , *Betula and Alnus* species

+ = Trace

-- = not tabulated

Black spruce seedlings were present during each sample year but only in small numbers (less than 600/ha). Bebb willow, sprouted from fire-killed stems and gray-leaf willow (source unknown), increased from densities of 2,500/ha and 0 respectively in 1978 to 6,200/ha and 3,100/ha in 1988. These were heavily browsed by moose.

See table 9.

Table 9
Species occurring after fire:
Open Needle Leaf Forest - Black Spruce/Tamarack (13-2)

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Picea Mariana	6	19	0	+	+	+	6	6	6
SHRUBS:									
Betula glandulosa	19	0	6	+	0	+	19	0	6
Salix spp.	25	81	93	+	0	+	19	0	6
Salix bebbiana	25	12	62	+	+	+	25	6	44
Salix glauca	0	0	31	0	0	+	0	0	6
Betula nana	–	–	–	+	3	2	+	19	12
Chamaedaphna calyculata	–	–	–	0	0	+	0	0	12
Ledum decumbens	–	–	–	6	6	12	75	69	81
Ledum groenlandicum	–	–	–	1	5	4	56	44	44
Rosa acicularis	–	–	–	0	+	0	0	6	0
Vaccinium uliganisum	–	–	–	5	6	12	100	81	94
Vaccinium vitis-idaea	–	–	–	2	2	3	62	81	75
HERBS:									
Calamagrostis canadensis	–	–	–	2	2	8	69	75	81
Carex sp.	–	–	–	+	+	+	6	6	6
Epilobium angustifolium	–	–	–	1	1	2	12	19	38
Equisetum arvense	–	–	–	0	+	+	0	6	6
Equisetum silvaticum	–	–	–	+	1	3	12	44	44
Rubus chamaemorus	–	–	–	+	0	0	19	0	0
Spiraea Beauverdiana	–	–	–	0	0	+	0	0	6
MOSSES AND LIVERWORTS:									
Moss (unidentified)	–	–	–	2	11	15	62	100	100
Polytrichum	–	–	–	1	0	2	44	0	88
Marchantia polymorpha	–	–	–	0	+	+	0	6	6

* (hundreds per hectare) Density data were collected for trees, *Betula* :, *Salix, and Alnus* species
+ = Trace
-- = not tabulated

Open Needle Leaf Forest - Black Spruce Tamarack (15-1). This was a very common and widespread community throughout the northern portion of the burn.

The original understory was composed of moss, bog blueberry and other wetsite species. The study site is poorly-drained but warm and level with continuous permafrost 60 to 64 cm below the surface. The soil is a cryohemist, a cold organic soil, over course, washed gravels on a flat outwash plain. At the time of the fire this stand was open, with 200 to 400 stunted trees/ha. The tree age distribution was distinctly bi-modal with peaks at 43 to 164 years. Ages ranged from 40 to 192 years for black spruce and from 44 to 46 years for tamarack. Diameters ranged from six to 10 cm at a breast height. Immediately after the fire, the dominant plants included the original understory species as well as fireweed, field horsetail and cottongrass.

Although all trees were killed, the fire burned with low intensity, only consuming five to 10 cm of the original 15-to 53-cm organic mat. The fire exposed small amounts of mineral soil near cottongrass/moss hummocks, which could possibly be frost boils; and 67 percent of the surface was charred or scorched. Unlike many other burned black spruce stands, this plot had nearly half of the trees felled possibly due to greater fire severity.

Between 1978 and 1980, several species increased, including mosses (11 percent cover to 59 percent), *M. polymorpha* (two percent to six percent), field horsetail (six percent to 12 percent), and fireweed (four percent to seven percent). By 1980 seven new species appeared including balsam poplar. Willow densities increased from 3,100/ha in 1978 to 4,400/ha in 1980. See table 10.

Open Needle Leaf Forest-Black Spruce/ Tamarack (17-1). This community is widely distributed throughout the burn.

The study plot is located between the shallow channels of a broad outwash plain. The soil is a cold, poorly-drained cryohemist, with a 58-cm organic mat. Permafrost was encountered at 58 cm in 1980.

The stand was about 48 years old, although one 90-year-old tree was found. Average density was 300 trees/ha. Diameters ranged from six to 12 cm and heights averaged 3.0 meters. The understory was dominated by cottongrass tussocks and feathermoss.

The surface fire burned severely but not intensely, charring about 86 percent of the surface and killing all trees. Approximately 18 to 38 cm of the original organic mat was consumed.

Post-fire regeneration was proceeding slowly during this three-year study period. Almost all species found on the site were survivors of the fire. Labrador tea, blueberry, bluejoint grass, fireweed, cottongrass, cloudberry, mosses and liverworts had cover values ranging from one to five percent in 1978. By 1980, most of these species had increased substantially including Labrador tea (two to eight percent), fireweed (three to 11 percent), cottongrass (four to nine percent), cloudberry (two to six percent), mosses (five to 23 percent), and *Polytricum* sp. (two to seven percent).

No tall shrubs or willows were present on the site. Black spruce seedlings with a frequency of 12 percent in 1978 and 19 percent in 1979 had disappeared in 1980.

Surface water present in small amounts in 1978 and 1979 covered 17 percent of the surface in 1980. There was no detectable change in depth of frozen soil. See table 11.

Open Low Scrub - Mixed Shrub Sedge Tussock Tundra (2-1, 2-2) This community is widespread in the southern portion of the burn and around Farewell. This area was burned in 1972 and reburned by the Bear Creek Fire (1977). The plot is level with frost boils. Soils are complex and poorly-drained having formed on a broad outwash plain. The site is very cold with frozen soil 70 cm below the surface. Frost action actively churns the soil in an annual cycle exposing mineral soil (Meyer, 1980).

Table 10
Species occurring after fire:
Open Needle Leaf Forest -
Black Spruce/Tamarack/Blueberry Community (15-1)

Species	Density* (Stems/ha)			Percent Cover			Percent Frequency		
	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Picea mariana	62	319	331	+	+	+	62	100	81
Populas balsamifera	0	0	62	0	0	+	0	0	6
SHRUBS:									
Alnus tenuifolia	0	6	0	0	+	0	0	6	0
Salix spp.	31	6	44	+	+	+	31	6	25
Salix novae-angliae	0	0	6	0	0	+	0	0	6
Betula nana	–	–	–	+	2	3	19	25	38
Chamaedaphnae calyculata	–	–	–	0	1	1	0	25	38
Ledum decumbens	–	–	–	0	+	0	0	25	0
Ledum groenlandicum	–	–	–	1	+	3	44	12	44
Potentilla fruticosa	–	–	–	0	+	0	0	+	0
Vaccinium uliginosum	–	–	–	4	4	5	81	81	69
Vaccinium vitis-idaea	–	–	–	0	0	+	0	0	6
HERBS:									
Calamagrostis canadensis	–	–	–	1	1	3	44	25	69
Carex sp.	–	–	–	2	4	2	62	88	44
Epilobium angustifolium	–	–	–	4	3	7	56	81	94
Equisetum arvense	–	–	–	6	3	12	100	81	94
Equisetum scirpoides	–	–	–	0	2	2	100	81	94
Equisetum silvaticum	–	–	–	0	1	2	0	50	62
Eriophorum sp.	–	–	–	+	+	+	12	6	12
Rubus chamaemorus	–	–	–	1	1	1	31	25	38
Sedge (unidentified)	–	–	–	3	0	0	62	0	0
MOSSES AND LIVERWORTS:									
Feathermoss	–	–	–	0	0	+	0	0	6
Moss (unidentified)	–	–	–	11	57	59	100	94	100
Polytrichum spp.	–	–	–	0	0	1	0	0	44
Marchantia polymorpha	–	–	–	2	5	6	81	86	88

*(hundreds per hectare) Density data were collected for trees, *Salix* and *Alnus species*
+ = Trace
-- = not tabulated

Before the Bear Creek Fire, the organic mat was was 2 to 25 cm thick with thin areas over the frost boils. Burning reduced this to 0 to 15 cm with mineral soil exposed on all frost boils leaving a mottled appearance. The plant community was dominated by cottongrass, dwarf birch, blueberry and willow.

The dominant species in the area are similar to those in the pre-burn community. Many of the less common species had disappeared by 1980, including lichens, avens, lupine, spruce seedlings, soapberry, mountain cranberry, *Festuca* sp. and *Carex* sp.

Table 11
Species occurring after fire:
Open Needle Leaf Forest - Black Spruce/Tamarack (17-1)

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Picea Mariana	12	19	0	+	+	0	12	19	0
SHRUBS:									
Betula nana	–	–	–	+	+	1	12	6	12
Chamaedaphne calyculata	–	–	–	+	+	1	0	25	6
Ledum decumbens	–	–	–	2	2	8	109	69	62
Vaccinium uliginosum	–	–	–	1	2	4	56	38	44
Vaccinium vitae-idaea	–	–	–	+	1	+	19	31	12
HERBS:									
Calamagrostis canadensis	–	–	–	1	+	4	25	12	25
Epilobium angustifolium	–	–	–	3	2	11	38	38	62
Equisetum arvense	–	–	–	0	0	+	0	0	6
Eriophorum sp.	–	–	–	4	7	9	50	44	50
Grass (unidentified)	–	–	–	0	0	+	0	0	6
Rubus chamaemorus	–	–	–	2	3	6	88	88	75
MOSSES AND LIVERWORTS:									
Moss (unidentified)	–	–	–	5	25	23	94	100	94
Polytrichum spp.	–	–	–	2	0	7	56	0	81
Marchantia polymorpha	–	–	–	1	+	1	25	19	12

*hundreds per hectare) Density data collected for tree species
+ = Trace

The Grayleaf willow, bluejoint, woodland horsetail and cottongrass increased from a range of two to seven percent cover in 1978 to a range of 11 to 14 percent cover in 1980. Moss cover increased from three to 28 percent and dwarf arctic birch decreased from four to one percent during the same time period. See table 12.

Open Low Scrub - Shrub Birch/Willow (3-1, 3-2) This is a fairly widespread community in the study area. The plot is located on a flat outwash plain, adjacent to an ablation moraine. The site is flat and well-drained; permafrost is absent. The soils are sandy and loamy over sandy glacial till. They are very warm and have flecks of charcoal mixed in the top 15 cm of loess. The plot was burned in 1972 and reburned by the Bear Creek fire. The control area was burned in 1972 but not in 1977. The nature of the 1972 fire on this site is unknown, although the thinness of the organic mat indicates that is was probably severe. The 1977 fire reburned the area severely. Only a 2 cm to 5 cm thin organic mat was present on the control plot with mineral soil, deadwood, unburned litter and scorched organic matter having cover values of zero percent, four percent, 36 percent and 18 percent. The remainder was covered by 28 percent moss and other low growing plants. On the burned 1977 plot, the same seedbeds covered 45 percent, 12 percent, 8 percent, and 13 percent. Only traces of moss and other low growing plants remain.

Table 12
Species occurring after fire:
Open Low Scrub - Mixed Shrub Sedge Tussock Tundra

	(2-2) Burned 1972						(2-1) Burned 1972 and 1977					
	Density* (Stems/ha)			Percent Cover			Density * (Stems/ha)			Percent Cover		
Species	78	79	80	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:												
Picea mariana	12	12	6	–	–	–	–	–	6	–	–	–
SHRUBS:												
Betula nana	–	–	–	11	10	19	–	–	–	4	1	1
Chamaedaphnae calyculata	–	–	–	0	0	1	–	–	–	0	+	+
Ledum decumbens	–	–	–	0	0	1	–	–	–	1	+	+
Ledum groenlandicum	–	–	–	1	3	2	–	–	–	0	+	+
Salix glauca	88	375	175	–	–	–	75	375	344	–	–	–
Salix myrtillifolia	12	194	81	1	3	2	6	88	234	–	–	–
Salix reticulata	–	–	–	+	0	+	–	–	–	0	0	0
Salix spp.	88	569	337	–	–	–	–	–	–	0	0	0
Vaccinium uliginosum	–	–	–	7	8	9	–	–	–	2	1	0
Vaccinium vitis-idaea	–	–	–	1	2	+	–	–	–	0	+	0
HERBS:												
Achillea borealis	–	–	–	+	+	+	–	–	–	1	+	+
Calamagrostis canadensis	–	–	–	2	7	6	–	–	–	4	5	12
Carex spp.	–	–	–	5	13	13	–	–	–	0	1	0
Compositae	–	–	–	0	0	0	–	–	–	5	0	0
Epilobium angustifolium	–	–	–	2	1	1	–	–	–	9	8	5
Equisetum arvense	–	–	–	0	1	+	–	–	–	3	2	1
Equisetum silvaticum	–	–	–	+	1	+	–	–	–	0	1	13
Eriophorum sp	–	–	–	19	17	24	–	–	–	2	6	12
Galium sp.	–	–	–	0	+	+	–	–	–	7	8	13
Grass (unidentified)	–	–	–	2	0	2	–	–	–	0	0	0
Lupinus arcticus	–	–	–	+	1	1	–	–	–	0	0	0
Luzulia multiflora	–	–	–	0	0	+	–	–	–	0	0	0
Pedicularis sp.	–	–	–	0	+	0	–	–	–	0	0	0
Petasites hyperboreus	–	–	–	6	6	10	–	–	–	1	2	4
Pyrola asariflolia	–	–	–	0	0	+	–	–	–	0	0	0
Rubus chamaemorus	–	–	–	2	2	3	–	–	–	1	3	3
Solidago multiradiata	–	–	–	+	+	+	–	–	–	0	1	0
MOSSES ANDLIVERWORTS:												
Feathermoss	–	–	–	0	0	2	–	–	–	0	0	0
Moss	–	–	–	4	12	13	–	–	–	3	16	28
Polytrichum sp.	–	–	–	0	0	4	–	–	–	0	0	0
Marchantia polymorpha	–	–	–	+	1	0	–	–	–	2	3	2
Sphagnum	–	–	–	0	0	1	–	–	–	2	3	2
LICHENS												
Cetraria cucullata	–	–	–	+	+	+	–	–	–	0	0	0
Cladonia spp.	–	–	–	0	0	+	–	–	–	0	0	0
Peltigera spp.	–	–	–	4	1	3	–	–	–	0	0	0

*(hundreds per hectare) Density data were collected for trees and *Salix* species
+ = Trace
-- = not tabulated

Prior to 1972, some scattered spruce were present on the adjacent control plot. These were killed by the Farewell Fire in 1972. Although the control plot community is dominated by dwarf birch and moss (35 percent and 28 percent cover), a significant grass understory (13 percent) is also present. Willows, ericaceous shrubs, fireweed and white birch seedlings are present in smaller quantities.

After the Bear Creek Fire, the only two species present in significant quantities on the plot burned in 1977 were fireweed and grass with respective cover values of 25 percent and two percent. No moss or white birch was observed on the newly burned site.

The severity of the 1977 reburn eliminated or drastically reduced the numbers of ericaceous shrubs and other plants that depend on vegetative reproduction to survive fire. Most species were eliminated and only those with light, wind dispersed seeds have returned strongly. Dwarf arctic birch, which had a coverage of 38 percent at the time of the second fire, was reduced to only one percent cover. This had increased to 20 percent by 1980 compared to an increase from 24 to 36 percent on the 1972 burn. Concomitantly, exposed mineral soil decreased form 45 to three percent on the 1977 reburn. Rock harlequin was found in the 1977 reburn in 1978 and 1979 but not 1980. It grew on the 1972 burn in 1979 only.

See tables 13 and 14.

Open Tall Scrub - Alder (4-2). The glacial moraines along the southeast edge of the 1977 burn supported a medium to tall shrub community. Slopes vary from zero to 45 percent with all aspects. The soils are warm and well drained loamy pergelic cryochrepts over sands and glacial till. Permafrost is absent. The preburn organic mat was probably less than 12 cm thick.

The pre-burn plant community on the study plot was composed of shrub birch, alder, and willow. Its understory was dominated by feathermoss, *Cladonia* spp., *Cetraria* spp., and foliose lichens. Mountain cranberry and Labrador tea also were present.

The severe fire reduced all plants and the organic mat to ashes, leaving mineral soil and a scattering of charcoal. Wind and water erosion further exposed mineral soil.

Bluejoint grass (one percent) and fireweed (two percent) were the only two vascular species with coverage of one percent or greater in 1978. Mosses and liverworts had a total coverage of 12 percent while paper birch, prickly rose and cranberry were present in small amounts.

By 1980, mosses and liverworts covered 60 percent of the area, fireweed covered 26 percent and bluejoint covered 5 percent. White spruce, willow, and balsam poplar seedlings germinated in 1979, but white spruce had disappeared in 1980. The site remains very dry and exposed to wind. The thin layer of moss should retain more moisture than the mineral soil could alone. See table 15.

Open Low Scrub - Mixed Shrub Sedge Tussock Tundra (12-1). Flat outwash plains between the major drainages in the southwestern portion of the 1977 burn were dominated by shrub bogs. The soil is a pergelic cryohemist, a very cold, poorly drained soil with free ground water at a depth of 38 cm. The organic mat is 43 cm thick over frozen silt-loam alluvium with numerous thin ice lenses.

On the study site the fire burned with low intensity and severity, scorching many plants. It generally burned less than five to 10 cm deep. No mineral soil was exposed. Before burning, the principal species were bog blueberry, mountain cranberry, labrador tea, and cottongrass. In 1978, cottongrass was the most abundant species with 19 percent cover. Sedges (*Carex* sp.) and labrador tea were also important with cover values of 12 percent and six percent respectively. Cottongrass tussocks, which sprouted from surviving rootstocks, produced prolific seedheads in 1978, 1979 and 1980. Tussocks in adjacent unburned communities produced few seedheads.

Table 13
Species Occurring after fire:
Open Low Scrub -
Mixed Shrub Sedge Tussock Tundra (3-2) burned 1972 only

Species	Density* (Stems/ha)			Percent Cover			Percent Frequency		
	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Betula papyrifera	0	0	0	–	–	–	0	0	0
Picea sp.	0	0	0	–	–	–	0	0	0
Populus balsamifera	0	0	219	–	–	–	0	0	69
Populus tremuloides	56	194	12	–	–	–	56	6	6
SHRUBS:									
Betula nana	–	–	–	35	38	43	100	94	100
Ledum decumbens	–	–	–	4	8	11	56	56	62
Salix glauca	44	188	100	–	–	–	44	38	25
Salix commutata	0	0	0	–	–	–	0	0	12
Salix novae-anglae	0	31	62	–	–	–	0	6	6
Salix myrtillifolia	–	–	–	0	0	69	–	–	–
Shepherdia canadensis	–	–	–	–	–	–	6	0	0
Salix spp.	–	219	231	–	–	–	0	31	0
Vaccinium uliginosum	–	–	–	2	0	3	62	0	69
Vaccinium vitis-idaea	–	–	–	0	0	69	94	88	100
HERBS:									
Achillea borealis	–	–	–	6	2	0	0	0	6
Aconitum delphinifolium	–	–	–	0	0	+	0	6	6
Calamagrostis canadensis	–	–	–	4	0	+	56	0	31
Composite (unidentified)	–	–	–	0	0	0	0	0	0
Cornus canadensis	–	–	–	1	2	1	–	–	–
Corydalis sempervirens	–	–	–	0	+	0	0	2	0
Epilobium angustifolium	–	–	–	4	5	10	100	94	100
Galium sp.	–	–	–	2	1	1	62	38	56
Grass (unidentified)	–	–	–	9	13	13	–	–	–
Lupinus arcticus	–	–	–	+	+	+	12	12	38
Pedicularis sp.	–	–	–	0	+	0	–	–	–
Solidago multiradiata	–	–	–	+	0	0	–	–	–
MOSSES AND LIVERWORTS:									
Moss	–	–	–	24	28	36	100	90	100
Polytrichum sp.	–	–	–	4	–	11	–	–	–

* (hundreds per hectare) Density data were collected for trees and *Salix* species
\+ = Trace
-- = not tabulated

Table 14
Species occurring after fire:
Open Low Scrub - Mixed Shrub Sedge Tussock Tundra (3-1)
burned 1972 and 1977

	Density* (Stems/ha)			Percent Cover			Percent Frequency		
Species	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Betula papyrifera	0	12	56	–	–	–	0	12	31
Picea sp.	0	0	6	–	–	–	0	0	0
Populus balsamifera	0	0	6	–	–	–	0	0	0
Populus tremuloides	0	50	25	–	–	–	0	0	6
SHRUBS:									
Betula nana	–	–	–	+	1	2	12	44	31
Salix glauca	6	0	6	–	–	–	0	0	0
Vaccinium vitis-idaea	–	–	–	0	+	+	0	6	12
HERBS:									
Achillea borealis	–	–	–	+	+	2	6	12	50
Calamagrostis canadensis	–	–	–	2	0	3	25	0	56
Composite (unidentified)	–	–	–	+	1	2	0	0	0
Corydalis sempervirens	–	–	–	+	+	0	12	12	0
Epilobium angustifolium	–	–	–	25	46	37	100	100	100
Equisetum scirpoides	–	–	–	0	+	1	0	19	31
Galium sp.	–	–	–	0	+	1	0	25	31
Grass (unidentified)	–	–	–	0	4	3	0	44	62
Lupinus arcticus	–	–	–	0	0	+	0	0	6
MOSSES AND LIVERWORTS:									
Moss	–	–	–	+	15	46	19	100	100
Marchantia polymorpha	–	–	–	+	1	2	19	38	62
Polytrichum sp.	–	–	–	0	0	2	0	0	75

* (hundreds per hectare) Density data were collected for trees and *Salix* species
+ = Trace
-- = not tabulated

There were no major changes in the number of species or dominance of species in 1979 or 1980. All species increased in coverage including cottongrass to 31 percent, Labrador tea to 13 percent, cloudberry to eight percent (from two percent), blueberry to nine percent, and mosses/liverworts from four to six percent.

Mesic Graminoid herbaceous - Bluejoint Herb (18-1). Scattered throughout the area, small bluejoint grass meadows formed in potholes and kettles in outwash plains and moraines. While the soil appears to be very poorly drained (as indicated by mottling near the surface), drainage appears to be improving. Apparently such features are sealed from surrounding shallow ground water by lacustrine deposits. This soil is much warmer and better drained than surrounding soils.

The original meadows were nearly pure stands of 5 to 1 m tall bluejoint grass. The grass on the study plot was burned to ground level without killing the roots.

Some of the meadows began to regenerate within a month after burning. Bluejoint grass had a coverage of 65 percent in 1978, increasing to 72 percent in 1979, and then decreasing to 48 percent in 1980. Plant heights were about 0.5 m in 1978 and about 1 m in 1979 and 1980. Almost no other species were present in any year.

Table 15
Species occurring after fire:
Open Tall Scrub - Alder Community (4-2)

Species	Density* (Stems/ha)			Percent Cover			Percent Frequency		
	78	79	80	78	79	80	78	79	80
TREE SEEDLINGS:									
Betula papyrifera	19	*	25	–	–	–	19	*	6
Picea glauca	–	12	–	–	–	–	–	12	–
Populas balsamifera	–	19	56	–	–	–	–	12	38
SHRUBS									
Rosa acicularis	–	–	–	+	+	1	6	6	6
Salix spp.	–	–	50	–	–	–	–	–	6
Vaccinium uliginosum	–	–	–	–	–	+	–	–	6
Vaccinium vitis-idaea	–	–	–	+	1	+	6	12	6
HERBS:									
Calamagrostis canadensis	–	–	–	1	1	5	19	6	75
Corydalis sempervirens	–	–	–	2	23	26	31	94	100
Epilobium angustifolium	–	–	–	4	3	7	56	81	94
Sedge (unidentified)	–	–	–	–	1	2	–	25	19
MOSSES AND LIVERWORTS:									
Moss (unidentified)	–	–	–	8	17	51	93	94	75
Polytrichum spp.	–	–	–	4	*	6	6	*	81
Marchantia polymorpha	–	–	–	4	8	3	100	100	81

* (hundreds per hectare) Density data were collected for trees and *Salix* species

+ = Trace

-- = not tabulated

SPECIFIC PLANTS

Black spruce. By far the best black spruce regeneration has occurred in two stands: a black spruce stand burned with moderate severity, where there were 33,100 seedlings/ha and 81 percent frequency in 1980, and in which charred organic matter was the main seedbed; and a lightly burned, closed-black spruce-paper birch stand with 40,000 seedlings/ha and 81 percent frequency. Again, greater than 85 percent of the seedbed was charred organic with 5 percent mineral soil exposed. The above deposits are similar to those found by Zasada et. al. (1979) in "lightly" burned black spruce stands. The crown fire in these stands did not destroy the semiserotinous cones of the black spruce.

Black spruce reproduction ranged between 600 and 1,900 seedlings/ha in all other stands regardless of burn severity and intensity. This is about one tenth of the density found by Zasada et. al.(1979). In one heavily burned black spruce stand, black spruce completely disappeared in 1980, after reaching a density of 1,900 seedlings/ha in 1979.

Zasada et al. (1979) pointed out that the variability of both seedfall and seed quality can be high. They demonstrated that high fire severity decreased seed germination. Weather also strongly influences seedling establishment and survival. Zasada (1978, personal communication) indicated that the major problem with a charred organic seedbed is its susceptibility to rapid changes in temperature and moisture. The cool, wet summers of 1978, 1979 and 1980 probably improved black spruce reproduction.

White Spruce. White spruce stands burned severely, exposing nearly 100 percent mineral soil and producing a good seed bed. Since the fire was of low intensity and most white spruce seeds are mature by August, it is likely that a good seed crop was available. White spruce regeneration was excellent (see table 6).

Good white spruce seed production occurs during hot, dry summers (Zasada and Gregory, 1969). Viereck and Schandelmeir (1980) point out that these summers are also correlated with the most active fire years. The summer of 1977 was hot and dry with an active fire period.

Some white spruce stands occurring as "stringers" along streams and rivers were burned much more lightly than adjacent black spruce stands. This might be due to high duff moisture in such stands, higher relative humidity resulting in somewhat higher fuel moistures and the lack of ladder fuels may be a factor in preventing crown fires.

Paper Birch and Aspen. Paper birch exhibited its capacity for both seed and vegetative reproduction. However, most regeneration was by seed. In the only stand which contained paper birch before burning, regeneration was extremely high despite the lack of exposed mineral soil.

The only aspen stand sampled was burned with heavy severity and high intensity, greatly retarding sucker regeneration (table 16). Aspen seed is mature in June and only viable for approximately one month.

Table 16
Comparison of Aspen Regeneration on Wickersham Dome Fire and on Bear Creek Fire

	Wickersham Dome			Bear Creek		
	1	2	3	1	2	3
Form of Regeneration	Stems/hectare			Stems/hectare		
Live Trees	0	0	0	0	0	0
Dead Trees	843	847	851	280	0	0
Saplings	0	6,514	27,208	0	0	0
Root Suckers	198,375	130,000	8,125	1,900	5,000	12,500
Total	198,375	136,514	35,333	1,900	5,000	12,500

The stand had only 1,900 stems/ha one year after the fire, less than one percent of the density on Wickersham Dome. Three years after the fire, density had increased to 12,500 stems/ha or about 28 percent of the density on Wickersham Dome. Mortality was very high on Wickersham Dome with 87 percent of the suckers dying by the third year. Density in the Bear Creek stand increased by 250 percent each year. Original tree density on Bear Creek was about 30 percent of the density on Wickersham Dome. It is likely that this resulted in lower regeneration density on Bear Creek but lack of regeneration is primarily due to the extreme fire severity. Plant vigor was much less on Bear Creek where no suckers had reached sapling size in three years compared to 80 percent of all stems on Wickersham Dome.

Shrubs. Gray-leaf willow is the most widely distributed tall shrub species in the Bear Creek area. It seldom reaches a height greater than one meter due to moose browsing, edaphic factors, and fire. Stem sprout regeneration is possible if 5 cm of the stem survive. The seed may survive in the soil as it lasts one year and longer.

In general, willow regeneration was best in communities which had thick organic mats before the fire. Even frequently reburned communities had good willow reproduction. If the organic mat was destroyed by severe burning; willow reproduction was very poor. A similar effect is evident where repeated fire destroyed the organic mat. On one site the Farewell Fire (1972) reduced, but did not completely destroy, the organic mat. This resulted in an increase in willow density from 1,800 stems/ha to 23,000 stems/ha in seven years. When Bear Creek Fire severely reburned this community, willow stems and seed were destroyed on the site eliminating willow from the community for these three years of sampling.

In general, willow has not reproduced well by seed, although seedlings are beginning to appear on some sites. One severely-burned white spruce community did not have any willow before or after the fire. Most white spruce communities burned by the Farewell Fire (1972) have produced abundant willow regrowth.

In shrub birch-willow stands on the moraine, shrub birch, willow and alder have been eliminated by the severe fire. Birch reproduce from basal stems though it is more susceptible to lower heat and more flammable due to peeling of the bark. Alder also sprouts from basal stems. Alder and shrub birch did survive and resprout in moderately burned black spruce communities where organic mat remained.

Dwarf arctic birch survived in small quantities even in severely reburned communities; this is due to pockets of lower burn severity . Most low shrubs regenerate by basal stem production and will survive moderate to light severity burns but will be destroyed by high severity. Labrador tea (primarily *Ledum decumbens*), bog blueberry, and blueberry all regenerated in their communities responding accordingly to severity. Mountain cranberry usually survived a single moderately severe fire but high severity fires and repeated light to moderate severity fires eliminated it from the site. Cranberry has thinner stems and is more likely to be destroyed than Labrador tea or birch.

Herbs. Bluejoint grass is very common and productive in all post-burn communities except the most severely burned dry sites (former aspen and white spruce stands). It can reproduce either vegetatively or by seed (Viereck and Schandelmeir, 1980). Bluejoint meadows which were burned to the root crowns in 1977, sprouted vigorously within one year, showing dense, tall production by the third year after the fire. Bluejoint grass is increasing in importance in most other communities regardless of burn severity or preburn community.

This trend can be expected to continue for many years. Foote (1976) showed that bluejoint grass was an important component of the understory in both black and white spruce stands for many years after burning.

Fireweed is the most abundant species in all communities except bluejoint meadows. It regenerated best in severely burned areas where fire had exposed mineral soil. When moisture was available, canopy coverage of fireweed reached as high as 60 percent and plants measuring up to one meter tall.

In low shrub and black spruce communities, the horsetails, *Equisetum arvense* and *E. Silvaticum* were present in significant numbers. Horsetail has deep rizomes to help regeneration as well as airborne spores. These communities shared the common factors of thick organic mats; cool, moderately wet sites; and moderate burn severity. Horsetail did not grow on very wet or cold sites. Dry sites were invaded by small amounts of E. Scirpoides which is more shallow rooted than the above species.

Cottongrass (*Eriophorum* spp.), primarily *E. vaginatum* reacted very positively to burning on most sites. Cottongrass demonstrates increased vigor after fire and its seeds and roots are difficult to destroy. Generally, these communities were not burned with high severity even when reburned. Individual tussocks sprouted vigorously with prolific seedhead production in the short term. Possibly the overall increase in vigor was a result of decreasing competition with mosses. Mosses are generally very important on cottongrass sites. In some cases, cottongrass was a very minor component of the original community.

Individual tussocks were covered with mosses leaving only a few leaves visible. The fire tended to remove the mosses from the interstices of tussocks exposing the cottongrass to light, and probably freeing nutrients and moisture.

In one case, the fire burned severely enough to reduce tussock thickness, killing most tussocks. The few that survived sprouted prolifically but the community has been largely replaced by bluejoint grass and *Polytricum* spp.

Mosses, Lichens, and Liverworts. All lichens and mosses were killed when burned, although a few survived in pits between tussocks. *Peltigera* sp. has begun to invade some of the less severely burned sites. In lightly burned areas, unburned patches are often present. These will provide a source of various species, which will be able to spread to adjacent burned patches.

The liverwort, *Marchantia polymorpha,* is very common in all communities where sufficient moisture was available (see white spruce/balsam poplar for further discussion).

EFFECTS ON SOILS AND SITE FACTORS

Organic Layer. Organic layers were reduced by 10 to 30 cm in black spruce stands or about 25 to 60 percent of the original mat thickness. On warm, well-drained sites under white spruce and shrub birch stands, the entire organic mat, usually two to 10 cm, was completely destroyed. This is quite high. Viereck and Dyrness (1979) found that only 20 to 30 percent of the organic mat was destroyed in heavily burned black spruce stands near Fairbanks. They found that a small percentage of the organic mat was destroyed in stands with thinner preburn mats. Opposite results were found at Bear Creek. Twenty to 80 percent of thick organic mats were removed by the fire; thin organic mats were totally destroyed.

Permafrost. Effects of the fire on permafrost were variable even within individual subplots. While subjective observations seem to indicate this was correlated with surface conditions, sampling was not sufficiently intensive or refined to demonstrate such correlations. It appeared that depth to frozen soil was progressively greater under the following surface conditions: unburned organic mat, scorched organic, charred organic, mineral soil, muck and standing water. In many communities, especially those with a black spruce overstory and shrub communities with thick organic mats, burning produced a variety of surface conditions, including several or all of those listed above.

Deadwood. The amount of deadwood on the forest floor was highly correlated with fire intensity and severity. On severely burned sites nearly all trees had fallen by the first summer following the fire. On moderate to light severity burn sites (usually black spruce communities) the remaining organic mat provided protection and support for roots. Roots and stems are not burned through, small stems will not erode for five -10 years and larger trees will stand 70-100 years. Most trees on these sites remained standing into the third year following the fire.

The number of trees standing is probably also related to intensity. Crown fires remove much of the surface area of the crown decreasing susceptibility to windthrow. These effects have also been observed on other burns such as the 1972 Farewell Burn. Black spruce in the Oskawalik River Burn (1959) were still standing when examined in 1980.

PLANT SUCCESSION IN RELATION TO SITE

Plant succession following fire is controlled by the site, preburn plant community, adjacent plant communities and fire characteristics (intensity, severity, and frequency of occurrence). It is too early to predict the probable patterns of succession on most sites. Only a recap of some of the more general observations is presented below.

Well-Drained Sites. Plant communities on drier sites (white spruce, hardwoods, and white spruce-black spruce forests) burned most severely. The severe fire produced a good seedbed for shrub and tree species in most cases and eliminated almost all vegetative reproduction. If these communities follow the patterns described by Foote (1976), they will regenerate to communities very similar to those which burned. Where white spruce forests burned, short term spruce regeneration is excellent with approximately 30,000 seedlings/ha. This is much different from the 350 seedlings/ha found by Foote (1976). It results from the late season fire and high burn severity. Even though high seedling mortality can be expected (Zasada et. al., 1978), tree regeneration should be good. Obviously this could change quickly if unfavorable weather conditions occur while the seedlings are still small.

Upland sites, usually underlain by permafrost, supported black spruce, black spruce-tamarack, and sedge-tussock communities. Burning was much less severe on these sites. The resulting communities are tundra-like, and dominated by blueberry, labrador tea, and other ericaceous shrubs, as well as sedges and mosses. On most sites where black spruce was present, seedlings are common, and the black spruce communities may return to their pre-1977 condition in 50 to 80 years. Repeated fires on some of these sites are perpetuating shrub and sedge-tussock communities.

Repeated fires at intervals frequent enough to prevent tree species from regenerating five to 25 years may eliminate trees and reduce the abundance of some shrub and herb species. This can result in low shrub herbaceous communities dominated by fireweed, grass, and other herbs. While fireweed dominance may decrease in future years, grass, willow and dwarf birch will continue to be major components for a long time.

Bluejoint grasslands located in dry lakebeds and potholes burned down to the rootstocks have already regenerated to their original condition.

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APPENDIX A

COMMON AND SCIENTIFIC NAMES OF PLANTS ON THE BEAR CREEK STUDY AREA

TREE SPECIES	
Betula papyrifera Marsh.	Paper birch
Larix laricina (Du Roi) K. Koch	Tamarack
Picea glauca (Moench) Voss	White spruce
Picea mariana (mill.) B.S.P.	Black spruce
Populus balsamifera L.	Balsam poplar
Populus tremuloides Michx.	Quaking aspen
SHRUB SPECIES	
Alnus crispa (Ait) Pursh	American green alder
Alnus sinuata (Reg.) Rydb.	Sitka alder
Alnus tenuifolia Nutt.	Thinleaf alder
Andromeda polifolia L.	Bog rosemary
Arctostaphylos alpina (L.) Spreng.	Alpine bearberry
Arctostaphylos rubra (Rehd & Wilson) Fern.	Red-fruit bearberry
Arctostaphylos uva-ursi (L.) Spreng.	Bearberry
Betula glandulosa Michx.	Resin birch
Betula nana L.	Dwarf arctic birch
Chamaedaphnae calyculata (L.) Moench	Leatherleaf
Dryas sp.	Avens
Dryas drummondii Richards	Drummond mountain-avens
Dryas integrifolia Vahl.	Entire-leaf mountain-avens
Dryas octopetala L.	White mountain-avens
Empetrum nigrum L.	Crowberry
Geocaulon lividum (Richards)	Fern
Juniperus communis L.	Common juniper
Ledum decumbens (Ait.) Small	Narrow-leaf Labrador-tea
Ledum groenlandicum Oeder	Labrador-tea
Linnaea borealis L.	Twin flower
Potentilla fruticosa L.	Bush cinquefoil
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay
Ribes triste Pall.	American red currant
Rosa acicularis Lindl.	Prickley rose
Salix sp.	Willow
Salix alaxensis (Anders.) Cov.	Feltleaf willow
Salix arbusculoides Anderss.	Littletree willow
Salix bebbiana Sarg.	Bebb willow
Salix brachcarpa Nutt. spp. *niphoclada* (Rydb.) Argus	Barren-ground willow
Salix commutata Bebb	Undergreen willow
Salix glauca L.	Rayleaf willow
Salix myrtillifolia Anderss.	Low blueberry willow
Salix novae-angliae Anderss.	High blueberry willow
Salix planifolia pursh. spp. *pulchra* (Cham.) Argus	Diamondleaf willow
Salix reticulata L.	Netleaf willow
Salix scouleriana Barratt.	Scouler willow
Shepherdia canadensis (L.) Nutt.	Bog cranberry
Vaccinium uliginosum L.	Bog blueberry
Vaccinium vitis-idaea L.	Mountain cranberry
Viburnum edule	Highbush cranberry

HERB SPECIES	
Achillea borealis Bong. spp.	Yarrow
Aconitum delphinifolium D.C. spp. *delphinifolium*	Monkshood
Amerorchis rotundifolia (Banks) Hult.	Round-leaved orchis
Anenome narcissiflora L.	Anenome
Arabis lyrata L. spp. *kamchatica* (Fisch.) Hult.	
Arnica alpina (L.) Olin spp *angustifolia* (M. Vahl) McGuire.	Alpine arnica
Artemisia Tilesii Ledeb. spp *elatior* (Torr. and Gray) Hult.	
Aster sibiricus L.	Aster
Astragalus L. sp.	Milk-vetch
Astragalus alpinus L. spp. *alpinus*	Elegant milk-vetch
Astragalus umbellatus Bunge	Tundra milk-vetch
Bupleurum triradiatum Adams spp. *arcticum* (Regel) Hult.	Thorough-wort
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint
Caltha palustris L. spp. *artica* (R. Br.) Hult	Marsh marigold
Carex L. sp.	Sedge
Claytonia sarmentosa C.A. Mey.	Spring beauty
Compositae	
Cornus canadensis L.	Bunchberry, Canadian dwarf cornel
Corydalis sempervirens (L.) Pers.	Pale corydalis, rock harlequin
Draba exalta Ekman	
Elymus innovatus Beal	Downy rye grass
Epilobium angustifolium L.	Fireweed
Epilobium latifolium L.	River beauty
Equisetum arvense L.	Field horsehair
Equisetum arvense L.	Meadow horsetail
Equisetum scirpoides Michx.	Dwarf horsetail
Equisetum silvaticum L.	Wood horsetail
Equisetum variegatum Schleich spp. *alaskanum* (A. Eat) Hult.	Variegated horsetail
Eriophorum sp.	Cotton grass
Eriophorum vaginatum L.	Cotton grass
Eritrichium splendens Kearney	Showy forget-me-not
Erysimum cheiranthoides L.	Wormseed
Festuca altaica Trin.	Red fescue grass
Festuca L. sp.	Fescue grass
Galium aparine L.	Bedstraw
Galium boreale L.	Northern bedstraw
Galium sp.	Bedstraw
Galium trifidum L.	Small bedstraw
Gentiana propinqua Richards	Gentiwan
Geum sp.	Avens
Geum macrophyllum Willd. spp.*perincisum* (Rydb) Hult.	
GRASS SPECIES	
Hedysarum alpinum L. spp. *americanum* (Michx) Fedtch.	Legume
Lupinus arcticus S. Wats.	Arctic lupine
Luzula multiflora (Retz.) Lej.	Woodrush
Lycopodium sp.	Club moss
Lycopodium clavatum L.	Running club moss
Mertensia paniculata (Ait.) G. Don spp. *paniculatas*	Tall bluebell
Oxytropis campestris (L.) D.C. spp. *gracilis* (Nels.) Hult.	Field oxytrope
Papaver lapponicum (Tolm.) Nordh. spp. *occidentale* (Lundstr.) Knaben	Arctic poppy
Parnassia palustris L. spp. *neogaea* (Fern.) Hult	Northern Grass-of-Parnassus
Parnassia sp.	Grass-of Parnassus
Parrya nudicaulis (L.) Regel	
Pedicularis L. sp.	Lousewort
Pedicularis capitata Adams	Capitate lousewort

Pedicularis parviflora J.E. Sm. spp.*pennellii* (Hult.) Hult.	Lousewort
Pedicularis verticillata L.	Whorled lousewort
Pedicularis Oederi M. Vahl	Oeder lousewort
Petasites frigidus (L.) Franch.	Arctic sweet colt's foot
Petasites hyperboreus Rybd.	Colt's foot
Polemonium acutiflorum Willd.	Blue Jacob's ladder
Polygonum L. sp.	
Potentilla uniflora redeb	One-flower cinquefoil
Pyrola sp.	Wintergreen
Pyrola asarifolia Michx.	Liverleaf wintergreen
Pyrola grandiflora Radius	Large-flower Wintergreen
Ranunculus sp. L.	Buttercup
Rorippa hispida (Desv.) Britt. spp. *hispida*	Marsh yellowcress
Rorippa islandica (oeder) Borb. spp.*fernaldiana* (Butte & Abbe) Hult.	Marsh yellowcress
Rubus arcticus L.	Nagoonberry
Rubus chamaemorus L.	Cloudberry
Rumex arcticus Trautv.	Arctic dock
Sanguisorba officinalis L.	Official burnnet
Saussurea angustifolia (Willd.) D.C.	
Saussurea sp. D.C.	
Senecio pauperculus (Michx.)	
Solidago multiradiata Ait.	Northern goldenrod
Spiraea Beauverdiana Schneid.	Beauvard spiraea
Spiranthes Romanzoffiana Cham.	Alaska bog-orchid
Stellaria laeta Richards.	Chickweed
Taraxacum lacerum Greene	Horned dandelion
Valeriana capitata Pall.	Capitate Valerian

<u>MOSSES AND FUNGI</u>

Polytrichum sp.
Sphagnum sp.

<u>LICHENS</u>

Cetraria cucullata (Bell.) Ach.	
Certraria ericetorum Opiz.	
Certraria nivalis (L.) Ach.	
Cladina sp.	
Cladonia sp.	
Cladonia mitis Sandst.	
Cladonia rangiferina (L.) Wigg	Reindeer Lichen
Dactylina arctica (Hook.) Nyl.	
Icmadophila sp.	
Marchantia Polymorpha	
Peltigera sp.	
Stereocaulon sp.	
Sticta sp.	
Thamnolia subuliformis (Ehrh.) Culb.	Plant Bones

APPENDIX B

PLOT SUMMARY
(based on Viereck/Dyrness 1986)

Ref. #	Plot #	Level III	Level IV	Level V
1	2-1	Open low shrub	Mixed shrub sedge tussock tundra	*Betula nana - Vaccinium uliginosum - Ledum palustre - Carex* sp. feathermoss
2	2-2	Open low shrub	Mixed shrub sedge tussock tundra	*Betula nana - Vaccinium uliginosum - Ledum palustre - Carex sp feathermoss*
3	3-1	Open low shrub	Shrub birch-willow	*Betula nana - Salix* sp. *- Calamatgrostis* sp.
4	3-2	Open low shrub	Shrub birch-willow	*Betula nana - Salix* sp. *- Calamatgrostis* sp.
5	4-1	Closed broadleaf forest	Aspen	*Populus tremuloidies* - unknown understory
6	4-2	Open tall shrub	Alder	*Alnus* sp.*- Betula* sp. *- Salix* sp *- Calamagrostis*
7	6-1	Closed mixed forest	Spruce - birch	*Picea mariana - Betula papyrifera - Ledum palustre - Vaccinium* sp.
8	7-1	Open needle leaf forest	Black spruce	*Picea mariana - Eriophrum* sp.
9	9-1	Wet graminoid herbaceous	Wet sedge meadow tundra	*Eriophorum* sp. *- Carex* sp *-Sphagnum* sp.*-Vaccinium uliginosum*
10	10-1	Wet graminoid herbaceous	Wet sedge meadow tundra	*Eriophorum* sp *- Carex* sp *-Sphagnum* sp.*-Vaccinium uliginosum*
11	11-1	Open needle leaf forest	Black spruce-white spruce	*Picea mariana - Picea glauca - Betula nana*
12	12-1	Open low shrub	Mixed shrub sedge tussock tundra	*Ledum palustre - Vaccinium* sp. *- Rubus chamaemrous*
13	12-2	Open Low shrub	Mixed shrub sedge tussock tundra	*Ledum palustre - Vaccinium* sp. *- Rubus chamaemrous*
14	13-1	Closed needle leaf forest	Black spruce-tamarack	*Picea mariana - Larix laricina - Vaccinium uliganosum*
15	13-2	Closed needle leaf forest	Black spruce-tamarack	*Picea mariana - Larix laricina - Vaccinium* sp.
16	14-1	Closed mixed forest	Spruce - birch - poplar	*Picea glauca - Populus balsmifera - Betula papyrifera* unknown understory

17	15-1	Open needle leaf forest	Black spruce-tamarack	*Picea mariana - Larix laricina - Vaccinium uliginosum* - moss
18	15-2	Open needle leaf forest	Black spruce-tamarack	*Picea mariana - Larix laricina - Vaccinium* sp.- moss
19	17-1	Open needle leaf forest	Black spruce-tamarack	*Picea Mariana -Larix Laricina* -Ericaceous Shrub -Eriophorum sp. moss
20	17-2	Wet graminoid herbaceous	Wet sedge meadow tundra	*Eriophorum* sp.- moss - *Rubus chamaemorus - Ledum palustre - Vaccinium uliganosum*
21	18-1	Mesic graminoid herbaceous	Bluejoint - herb	*Calamagrostis canadensis*
22	18-2	Open needle leaf forest	Black spruce	*Picea mariana - Eriophorum* sp. - Ericaceous shrub
23	19-1	Mesic graminoid herbaceous	Tussock tundra	*Eriophorum* sp. - moss - *Vaccinium uliganosum - Salix* sp.
24	19-2	Mesic graminoid herbaceous	Bluejoint herb	*Calamagrostis* sp.- *Carex* sp.- moss

APPENDIX C

Pre-1977 PLANT COMMUNITY
(Level V: Dyrness and Viereck, 1978)

Reference Number	Plot Number	Species
1	2-1	*Betula nana - Vaccinium uliginosum - Ledum palustre/Carex* sp. - feathermoss
2	2.2	*Betula nana - Vaccinium uliginosum - Ledum palustre/Carex* sp. - feathermoss
3	3-1	Betula nana - Salix spp./*Calamagrostis* sp. - feathermoss
4	3-2	*Betula nana - Salix* spp./*Calamagrostis* sp. - feathermoss
5	4-1	*Populus temuloides*/unknown understory
6	42	*Alnus* sp. - *Betula* spp. - *Salix* spp./*Calamagrostis* sp.
7	61	*Picea mariana - Betula papyrifera/Ledum palustre* - *Vaccinium* spp.
8	7-1	*Picea mariana/Eriophorum* sp. - moss
9	91	*Eriophorum* sp. - *Carex* sp. - *Sphagum* spp./*Vaccinium uliginosum*
10	101	*Eriophorum* sp. - *Carex* sp. - *Sphagnum* spp./*Vacciniumuliganosum*
11	111	*Picea mariana - Picea glauca/Betula nana*
12	121	*Ledum palustre - Vaccinium* spp./*Rubus chamaemorus -Eriophorum* sp.
13	122	*Ledum palustre - Vaccinium* spp./*Rubus chamaemorus -Eriophorum* sp.
14	131	*Picea mariana - Larix lariciana/Alnus* spp. *Vaccinium uliginosum*/moss
15	132	*Picea mariana - Larix laricina/Ledum plalustre - Vaccinium* spp./moss
16	141	*Picea glauca - Poplus balsamifera - Betula papyrifera*/unknown understory
17	151	*Pica mariana - Larix laricina/Vaccinium uliginosum* - moss
18	152	*Picea mariana - Larix laricina/Vaccinium* spp. - moss
19	171	*Picea mariana - Larix laricina*/Ericaceous *Shrub/Eriophorum* sp. - moss
20	172	*Eriophorum* sp. - moss - *Rubus chamaemorus/Ledum palustre - Vaccinium uliginosum*
21	181	*Calamagrostis canadensis*
22	182	*Picea mariana/Eriophorum* sp./Ericaceois Shrub
23	191	*Eriophorum* sp. - moss/*Vaccinium uliginosum - Salix* spp.
24	192	*Calamagrostis* sp. - *Carex* sp. - herb

APPENDIX D

PLANT COVER CLASSES

Reference Number	Plot Number	Class
1	2-1	Birch and Ericaceous-Sedge Shrub Tundra
2	2-2	Birch and Ericaceous-Sedge Shrub Tundra
3	3-1	Open Dwarf Birch Shrubland
4	3-2	Open Dwarf Birch Shrubland
5	4-1	Closed Aspen Forest
6	4-2	Open Mixed Tall Shrub
7	6-1	Closed Spruce-Birch Forest
8	7-1	Woodland Black Spruce
9	9-1	Sedge Tussock-Ericaceous Shrub Tundra
10	10-1	Sedge Tussock-Ericaceous Shrub Tundra
11	11-1	Open Black Spruce-White Spruce
12	12-1	Birch and Ericaceous-Sedge Shrub Tundra
13	12-2	Birch and Ericaceous-Sedge Shrub Tundra
14	13-1	Closed Black Spruce-Tamarack
15	13-2	Closed Black Spruce-Tamarack
16	14-1	Closed Poplar-Spruce
17	15-1	Open Black Spruce-Tamarack
18	15-2	Open Black Spruce-Tamarack
19	17-1	Woodland Black Spruce-Tamarack
20	17-2	Sedge Tussock-Ericaceous Shrub Tundra
21	18-1	Bluejoint Meadow
22	18-2	Open Black Spruce
23	19-1	Woodland Black Spruce
24	19-2	Bluejoint-Sedge-Herb Grassland

APPENDIX E

Hectare to Acre Conversion

Hectares	Acres
1.00	2.47
5.00	12.36
10.00	24.71
50.00	123.55
100.00	247.10
500.00	1,235.50
1,000.00	2,471.00
5,000.00	12,355.00
10,000.00	24,710.00
50,000.00	123,550.00
100,000.00	247,100.00
500,000.00	1,235,500.00
1,000,000.00	2,471,000.00
5,000,000.00	12,355,000.00

Acres	Hectares
1.00	0.40
5.00	2.02
10.00	4.05
50.00	20.23
100.00	40.47
500.00	202.35
1,000.00	404.69
5,000.00	2,023.47
10,000.00	4,046.94
50,000.00	20,234.72
100,000.00	40,469.45
500,000.00	202,347.23
1,000,000.00	404,694.46
5,000,000.00	2,023,472.28

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